Micro-angeional Conference, 1st, Burlington, Vt., 1966.

Micro-Vascular Surgery

Report of First Conference, October 6–7, 1966
Mary Fletcher Hospital, Burlington, Vermont

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217 illustrations

The C.V. Mosby Company · Saint Louis
Georg Thieme Verlag · Stuttgart 1967

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Bipolar Coagulation in Microsurgery

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The discussion of a coagulation technique seems, at first thought, out of place in a symposium devoted mainly to the reconstruction and repair of small vessels. However, in order to reconstruct a small vessel it is first necessary to have a meticulous exposure and isolation in a clear and bloodless field. The microsurgical bipolar coagulator can be of considerable aid in this procedure.

In 1940, Greenwood (1, 2, 3) introduced the use of two point coagulation to neurosurgery. His first description of the technique included a specially designed forceps with the two blades insulated from each other. One blade was connected to the patient ground socket of the standard Bovie coagulation unit and the other blade was connected to the active electrode socket of the Bovie unit. A hand switch was used to disconnect the special forceps and to reconnect the ground plate and active electrode when the unipolar current was to be used. Greenwood demonstrated the advantages of the two point coagulation technique and proved its greater safety in critical areas of neurosurgical procedures.

Certain technical limitations prevented the full adoption of the method, however. The usual operating room unipolar coagulating machine is not designed to be isolated from ground. The indifferent or "patient" connection of these machines ordinarily has a fairly low impedence to ground even when disconnected from the patient. Also, in the modern operating room the patient generally has other connections (as to monitoring equipment) more or less adequately grounding his body. As a result the active electrode of the machine will still be a current source even when the ground plate is not connected. Therefore, when the bipolar forceps is connected to the unipolar type of coagulator, one blade tends to be active and may still produce a fair amount of current spread to the patient even if the other blade of the forceps is not in contact with the tissue.

In 1958, the present author built a new instrument specifically for bipolar coagulation. A damped wave spark unit was designed to provide a completely isolated output so that with the machine grounded there was negligibly low ground leakage from either electrode connection. The output wave form was shaped by matching transformer impedances with the rest of the circuitry so that a wave form was provided which caused minimal muscle stimulation for the amount of coagulation produced. The machine was designed for a continuous duty cycle, in order to provide a high degree of reliability. The units were then made available commercially with the most recent models utilizing a ten step switched control of intensity for reliable reproduction of the coagulation level (Fig. 1). For general neurosurgical work the instrument is set at # 5 or # 6 and is rarely used higher than # 6. In working around the spinal cord and brain stem a setting of # 3 or # 4 is most often used with the standard forceps. If the fine forceps designed for work under the operating microscope are employed the usual setting is # 2. The # 1 setting is used only for very fine vessels under the microscope at powers above 15 diameters with very fine pointed forceps.

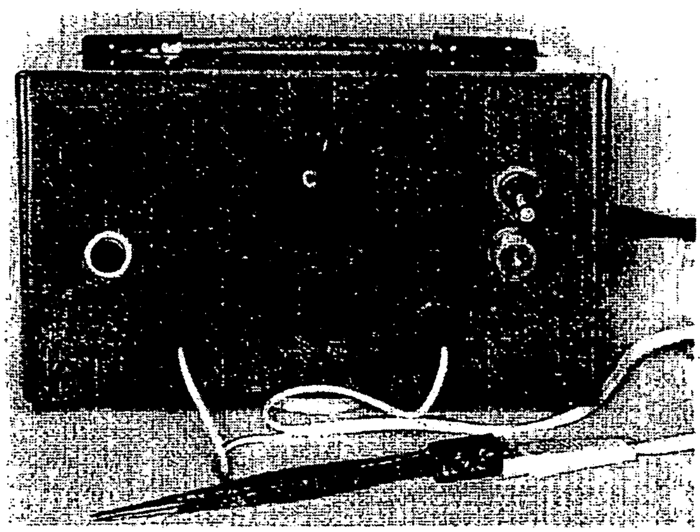

Fig. 1 The complete bipolar coagulator unit, with miniature forceps attached.

In the bipolar coagulation system, the current is restricted to the shortest path between the two electrode tips. There is no significant current flow from either electrode tip to ground or the patient in general. When the electrode tips touch each other the current is short circuited and no coagulation occurs. It is, therefore, essential that the vessel or tissue to be coagulated be held between the electrode tips and that the tips do not contact each other. Since the current flow is concentrated in the shortest path between the two electrode tips, it is not necessary to coat the blades of the forceps with insulation. In the experimental laboratory, for acute studies, the uninsulated forceps is often used barehanded without burning or shocking the experimenter. Coagulation may be carried out under a pool of saline solution as demonstrated in figure 2 where the forceps is immersed in saline. For a more obvious photograph the

Fig. 2 The forceps is shown immersed in saline solution. In order to demonstrate the current concentration between the forcep tips photographically, the power was set to maximum, causing a spark between the electrode tips and local boiling of the saline.

power was turned up to # 10 so that an actual spark would appear to show the area of current flow. The stream of bubbles is coming from the tip as a result of local boiling of the saline at this very high power setting. Nevertheless even in this situation significant passage of current takes place only between the tips of the forceps. Saline irrigation is used during the course of all coagulations with the bipolar coagulator, thereby preventing any significant degree of tissue heating and minimizing shrinkage, drying and sticking to the forceps. If the forceps is used in a dry field without saline irrigation or under a layer of blood, there is a tendency for the forceps tips to be coated with a baked layer of charred blood which effectively

insulates the points and prevents any further coagulation. This layer would be best scraped away with a scalpel blade. Even better, it should be prevented from occurring whenever possible by the use of saline irrigation.

In routine neurosurgery, major vessels, such as the middle meningeal, superficial temporal, or occipital arteries are readily closed with the bipolar unit. However, such vessels are readily occluded by ligature or clip or unipolar techniques. The most important advantage of the bipolar method in neurosurgery is its ability to handle vessels in areas where the use of the unipolar coagulating current would be hazardous. The dissection of an angle tumor from the pons can be handled bloodlessly without damaging the pons by current spread or heating, by picking up the individual vessels on the tumor capsule along the brain stem and coagulating while a small amount of saline is irrigated over the forceps. Ransohoff et al. (4) have pointed out the improvement in angle tumor surgery that this technique allows. In cordotomy, vessels on the antero-lateral surface of the cord may be coagulated by stroking the cord with the forceps tips separated about a millimeter leaving a clearly demarcated thin line of coagulation through which the incision may be made. It is possible to do the actual separation of the anterior quadrant of the cord using the bipolar coagulator to coagulate the substance of the cord itself under direct vision. With the saline running on the field this is accomplished without danger of damage to the rest of the spinal cord by current spread or heating.

The ability to coagulate a very small tissue volume without current spread permits the application of the technique to meticulous hemostasis of skin flaps as in plastic surgery. The amount of devitalized tissue can readily be reduced to less than that of even precise use of fine ligatures, and postoperative reaction appears to be distinctly less marked.

For microsurgical work a special bipolar forceps has been developed. This forceps is illustrated in figure 2. A rather delicate forceps has been separated and then bolted back together with its blades insulated by fiber sleeves after the standard telephone relay technique. The rebuilt area is then potted in a high temperature epoxy for permanence. Two contacts are brought out, one from each blade of the forceps, to fit a standard type of electric razor cord which was selected for its lightness and the fact that its excellent quality of rubber would withstand repeated autoclaving. In addition, the limpness of these cords which are designed for repeated flexing minimizes the drag on the operator's hand. When necessary for work on extremely fine vessels under very high magnifications we have preferred to hand hone the tips of the forceps to even finer points than provided on the commercially available miniature bipolar.

With this forceps the isolation of small vessels becomes much more feasible since their tiny branches may be coagulated when necessary to permit the isolation of a sufficient segment to permit reparative or anastomotic surgery. Using very low currents under saline, it is possible to even seal tiny holes of vasa vasorum without appreciable shrinkage in the wall of the vessel being manipulated. Tiny bleeders may show up as very fine streams in a saline pool under the microscope. The source of such a bleeder may be difficult to see if the saline is removed from the field, but with the fine bipolar, the tiny bleeding point may be picked up under the saline and readily controlled. Subpial and subarachnoid diffusion of blood may thereby be prevented and

prolonged waiting with the application of pressure on cottonoids to control such oozing may be avoided.

The use of the bipolar coagulation technique allows hemostasis to be made of almost any size vessel encountered in neurosurgical procedures, from vessels as large as the superficial temporal down to vessels too small to ligate or too small for the application of a silver clip. This may be done, as has been pointed out, in areas where ordinary unipolar coagulation with its attendant current spread would be dangerous or impossible.

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Laser Theory and Biomedical Application*

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Although the properties of laser light were theorized many years ago (4). Maiman fabricated the first working laser unit (1). In the ensuing half dozen years the field has grown enormously. Two papers were published in 1959, 6,000 papers were published by 1965.

Many biomedical applications for laser energy have been envisioned, by both the general public and medical profession. This presentation is designed to enable the physician interested in the field to better understand the theory of laser and the reasons for choosing a specific laser for certain biomedical problems.

Firstly, what is a laser? This word conveniently shortens to workable length the descriptive words — Light Amplification by Stimulated Emission of Radiation. Laser light is unique in the following respects. It is monochromatic — a single wavelength. It is extremely intense — it is the most powerful form of light known. The beam is absolutely coherent — this means that the light output eminates from the source as a sinosoidal wave and not as a mixture of wavefronts. Moreover, the light beam, for all practical purposes, contains parallel rays. Indeed, a laser beam projected from earth

* From the Henry L. and Lucy Moses Surgical Research Laboratory and the Surgical Division, Montefiore Hospital and Medical Center, New York City.

Aided by a grant from the John A. Hartford Foundation.

The authors gratefully acknowledge the assistance of Dr. M. Polanyi and Dr. E. Snitzer of the Research Division, American Optical Company, Southbridge, Mass. and Dr. T. Polanyi and Mr. M. Bliven of Laser Inc., a subsidiary of The American Optical Company.